PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : A61F 13/15, B05B 7/14

A1

(11) International Publication Number: **WO 00/33783**

(43) International Publication Date: 15 June 2000 (15.06.00)

(21) International Application Number: PCT/US99/29470

(22) International Filing Date: 10 December 1999 (10.12.99)

(30) Priority Data:

| | | |
|---|---|---|
| 60/111,881 | 11 December 1998 (11.12.98) | US |
| 09/421,720 | 20 October 1999 (20.10.99) | US |

(71) Applicant: KIMBERLY-CLARK WORLDWIDE, INC. [US/US]; 401 North Lake Street, Neenah, WI 54956 (US).

(72) Inventors: ROOYAKKERS, John, Anthony; 716 Lori Lane, Little Chute, WI 54140 (US). FELL, David, Arthur; 2055 Lynn Drive, Neenah, WI 54956 (US). HALLORAN, Thomas, Joel; 2473 Westpoint Road, Green Bay, WI 54304 (US). NIEMI, Paul, Martin; 8923 Clayton Avenue, Neenah, WI 54956 (US). OLSEN, Martin, Karl; 2245 Thrush Lane, Neenah, WI 54956 (US). SCHUELER, Kenneth, Raymond, Jr.; 812 West Summer Street, Appleton, WI 54914 (US). TIPPEY, Darold, Dean; N206 Country Ayre Court, Appleton, WI 54915 (US).

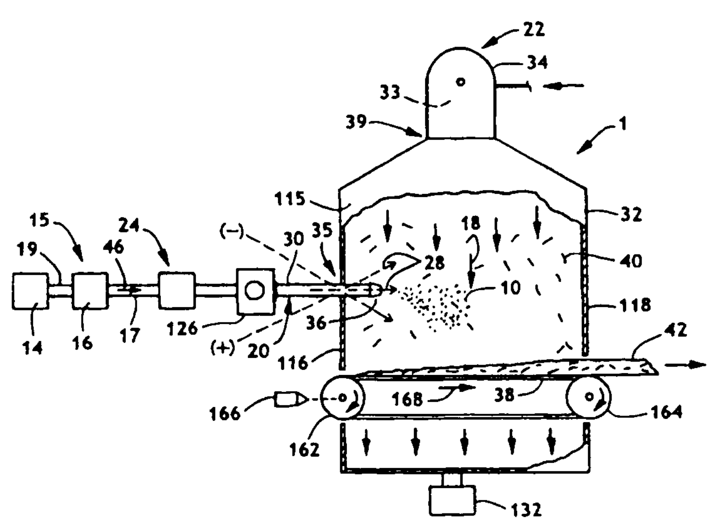
(74) Agents: CHARLIER, Patricia, A. et al.; Kimberly-Clark Worldwide, Inc., 401 North Lake Street, Neenah, WI 54956 (US).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published**

*With international search report.*
*Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.*

(54) Title: PROCESS FOR UNIFORM CROSS-DIRECTION DISTRIBUTION OF PARTICULATE MATERIAL




(57) Abstract

A method for forming a substantially uniform distribution of particulate material within a fibrous web includes a conveying step for providing a gas entrained supply of the particulate material. A transferring step directs the particualte material into a delivery gas stream through a delivery conduit and delivery nozzle into a web forming chamber. A fiberizing step provides a flow of a selected fibrous material into the web forming chamber. A foraminous forming layer is disposed within the forming chamber for receiving the fibrous material and the particulate material to produce a fibrous web.

*FOR THE PURPOSES OF INFORMATION ONLY*

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AL | Albania | ES | Spain | LS | Lesotho | SI | Slovenia |
| AM | Armenia | FI | Finland | LT | Lithuania | SK | Slovakia |
| AT | Austria | FR | France | LU | Luxembourg | SN | Senegal |
| AU | Australia | GA | Gabon | LV | Latvia | SZ | Swaziland |
| AZ | Azerbaijan | GB | United Kingdom | MC | Monaco | TD | Chad |
| BA | Bosnia and Herzegovina | GE | Georgia | MD | Republic of Moldova | TG | Togo |
| BB | Barbados | GH | Ghana | MG | Madagascar | TJ | Tajikistan |
| BE | Belgium | GN | Guinea | MK | The former Yugoslav Republic of Macedonia | TM | Turkmenistan |
| BF | Burkina Faso | GR | Greece | | | TR | Turkey |
| BG | Bulgaria | HU | Hungary | ML | Mali | TT | Trinidad and Tobago |
| BJ | Benin | IE | Ireland | MN | Mongolia | UA | Ukraine |
| BR | Brazil | IL | Israel | MR | Mauritania | UG | Uganda |
| BY | Belarus | IS | Iceland | MW | Malawi | US | United States of America |
| CA | Canada | IT | Italy | MX | Mexico | UZ | Uzbekistan |
| CF | Central African Republic | JP | Japan | NE | Niger | VN | Viet Nam |
| CG | Congo | KE | Kenya | NL | Netherlands | YU | Yugoslavia |
| CH | Switzerland | KG | Kyrgyzstan | NO | Norway | ZW | Zimbabwe |
| CI | Côte d'Ivoire | KP | Democratic People's Republic of Korea | NZ | New Zealand | | |
| CM | Cameroon | | | PL | Poland | | |
| CN | China | KR | Republic of Korea | PT | Portugal | | |
| CU | Cuba | KZ | Kazakstan | RO | Romania | | |
| CZ | Czech Republic | LC | Saint Lucia | RU | Russian Federation | | |
| DE | Germany | LI | Liechtenstein | SD | Sudan | | |
| DK | Denmark | LK | Sri Lanka | SE | Sweden | | |
| EE | Estonia | LR | Liberia | SG | Singapore | | |

# PROCESS FOR UNIFORM CROSS-DIRECTION DISTRIBUTION OF PARTICULATE MATERIAL

## THE FIELD OF THE INVENTION

The present invention relates to a method for forming a substantially uniform distribution of particulate material within a fibrous web. More particularly, the present invention relates to a method for forming a substantially uniform distribution of superabsorbent polymer particles within the cross direction of an absorbent pad composed of hydrophilic fibers.

## BACKGROUND OF THE INVENTION

Absorbent articles, such as disposable infant diapers, feminine care products, incontinence garments and the like, have included high absorbency superabsorbent polymers to increase the absorbent capacity of the article and to reduce the bulkiness of the article.

Various devices and processes have been employed to manufacture absorbent article designs. Air forming techniques for forming webs of hydrophilic fibers, such as woodpulp fibers, are well known in the art. In addition, it is well known that superabsorbent polymers may be mixed with the hydrophilic fibers during an airlaying process to form an absorbent web. For example, see the Sanyo Technical Bulletin entitled "SAP SHEET", dated October 1982.

Various methods and apparatus have been employed to manufacture absorbent articles. For example, U.K. Patent Application, No. GB 2,150,033 A published June 26, 1985, describes a suction drum apparatus for making an absorbent pad wherein an integrated shell of flocculent material surrounds an internal absorbent layer. U.S. Pat. No. 4,087,508 issued May 2, 1978 to Cook et al. describes a method which includes applying hydrocolloid polymer particles onto the surface of a central zone of a moving web, and distributing the applied particles into the body of the moving web by air-pressure means.

International Patent Application No. WO 88/04165 published June 16, 1988 describes a method and apparatus for forming a nonwoven pad consisting of fibrous material in which highly moisture-absorbent particles are intermixed with the fibrous material throughout a predetermined portion of the thickness of the nonwoven pad. It further describes a spray gun or an extension thereof positioned within the chamber relative to the fibrous material atop a conveyor and that is operated to discharge moisture-absorbent material at a predetermined velocity, such that the moisture-absorbent material is intermixed with the fibrous material throughout a central layer of the thickness of the nonwoven pad while forming boundary layers on either side of the center layer which are substantially free of moisture-absorbent material. Additionally, the spray gun preferably operates intermittently to form spaced, sharply defined areas along the length and width of the nonwoven pad wherein each area has moisture absorbent material interspersed throughout a portion of the thickness thereof.

Conventional methods, such as those described above, have not been sufficiently satisfactory. For example, the methods may be overly complex and expensive and may not provide desired uniform deposition for particulate materials, such as superabsorbent granules. The rate of delivery of the superabsorbent particles may not be adequately controlled, and the systems may be excessively sensitive to changing bulk densities in the particulate material.

## BRIEF DESCRIPTION OF THE INVENTION

The present invention provides a method for forming a substantially uniform (zoned or otherwise) distribution of particulate material within a fibrous web. Generally stated, a method of the present invention may be practiced using an apparatus as described below. The conveying means provides a gas entrained supply stream of the particulate material. The transferring means directs the particulate material into a delivery gas stream to provide a constant or intermittent flow of a selected quantity of particulate material, a delivery conduit, and a delivery nozzle into a web forming chamber. The fiberizing means provides a flow of a selected fibrous material into the web forming chamber, and directing means controls the flow of the particulate material from the delivery conduit, through the delivery nozzle, into the web forming chamber. A foraminous forming layer is disposed within the web forming chamber for receiving the fibrous material and the particulate material to form a fibrous web having a substantially uniform distribution of the particulate material. Such a distribution may include zoned regions having selected, different amounts of the particulate material therein.

The present invention can further provide a method for forming a substantially uniform distribution of particulate material within the cross direction of a fibrous web. In this aspect of the present invention, the method comprises the steps of providing a gas entrained supply stream of the particulate material. The particulate material is transferred into a delivery gas stream to provide a flow of particulate material through a delivery conduit and delivery nozzle into a web forming chamber. A flow of a selected fibrous material is provided into the web forming chamber, and the flow of particulate material from the delivery nozzle into the forming chamber. The fibrous material and particulate material are received on a foraminous forming layer located within the forming chamber to produce a fibrous web.

Another aspect of the present invention is a distinctive absorbent article comprising a substantially unitary web composed of a mass of hydrophilic fibers, and a quantity of superabsorbent polymer particles substantially uniformly located in the cross direction of the fibrous mass. The superabsorbent particles may have a distinctive, non-uniform distribution along a longitudinal, length dimension of the web. The weight percentage of superabsorbent (per unit weight of the combined particles and fiber) also may be non-uniformly distributed along the length dimension and in the thickness

dimension. In particular aspects of the present invention, the absorbent article can also include a longitudinal, length-wise particle distribution that is substantially configured in the form of two or more stepped stages.

The present invention can advantageously provide a method which, when compared to conventional devices, can more efficiently substantially uniformly distribute the particulate material within the cross direction of a fibrous web, and can position the particulate material in a manner which is generally independent of the flow of fibrous material employed to form the web. In the present invention, the method provides a substantially uniform cross-direction particulate distribution within the fibrous web. A further advantage of the present invention is that the method can operate at high speeds. The method also prevents the non-uniform distribution of the particulate material within cross direction of the absorbent article wherein the absorbent article includes a region with a zoned application in the machine direction. The method also prevents a non-uniform distribution of the particulate matter within the cross direction of the absorbent article wherein the absorbent article includes a non-uniform basis weight of fibers in the machine direction and cross direction (pocket forming and profiles). It has been noted that using current method_causes a non-uniform distribution of the particulate material in the cross direction.

The distinctive absorbent article of the present invention can advantageously provide a more efficient use of the absorbent material and provide a more effective, localized placement of superabsorbent particles within a web or pad composed of hydrophilic fibers.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more fully understood and further advantages will become apparent when reference is made to the following detailed description of the invention and the drawings, in which:

**FIGURE 1** representatively shows a schematic system diagram of the invention;

**FIGURE 2** representatively shows a schematic system diagram of the invention;

**FIGURE 3** representatively shows a front view of a current delivery nozzle;

**FIGURE 4** representatively shows a cross section view of a fibrous web;

**FIGURE 5** is a photograph of a cross section view of an absorbent body with the superabsorbent material in a swollen and stained state;

**FIGURE 6** representatively shows a side view of a delivery nozzle of the present invention;

**FIGURE 7** representatively shows a top view of a delivery nozzle of the present invention;

**FIGURE 8** representatively shows a side view of a delivery nozzle of the present invention;

**FIGURE 9** representatively shows a front view of a delivery nozzle of the present invention;

**FIGURE 10** representatively shows a side view of a delivery nozzle of the present invention;

**FIGURE 11** is a photograph of a cross section of an absorbent body with the superabsorbent material in a swollen and stained state;

**FIGURE 12** representatively shows a front view of a delivery nozzle of the present invention;

**FIGURE 13** representatively shows a side view of a delivery nozzle of the present invention;

**FIGURE 14** is a photograph of a cross section of an absorbent body with the superabsorbent material in a swollen and stained state;

**FIGURE 15** representatively shows a side view of a delivery nozzle of the present invention;

**FIGURE 16** representatively shows a top view of a delivery nozzle of the present invention;

**FIGURE 17** representatively shows a front view of a delivery nozzle of the present invention;

**FIGURE 18** representatively shows a front view of a delivery nozzle of the present invention;

**FIGURE 19** representatively shows a side view of a delivery nozzle of the present invention;

**FIGURE 20** is a photograph of a cross section of an absorbent body with the superabsorbent material in a swollen and stained state; and

**FIGURE 21** representatively shows an absorbent diaper-type article which incorporates an absorbent body of the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

The following detailed description will be made in the context of depositing particulate material **10**, such as superabsorbent particles within a web employed to construct an absorbent body for use in a disposable absorbent article **210** such as a disposable diaper. It should be understood, however, that the present invention may also be employed to incorporate other types of particulate material within a mass of hydrophilic or hydrophobic fibers. In addition, it should be readily understood that the present invention may also be employed to produce absorbent bodies for other types of absorbent articles, such as feminine care products, incontinence articles and the like. All of such alternative configurations are contemplated as being within the scope of the present invention.

The present invention is a method that is particularly useful for depositing particulate material **10**, such as organic or inorganic high absorbency material (e.g. superabsorbent), within a fibrous web **42**. Suitable inorganic high-absorbency materials include, for example, absorbent clays and silica gels. Organic high-absorbency materials

can include natural materials, such as agar, pectin, guar gum and peat moss, as well as synthetic materials, such as synthetic hydrogel polymers. Such hydrogel polymers include, for example, carboxymethylcellulose, alkali metal salts of polyacrylic acids, polyacrylamides, polyvinyl ethers, hydroxypropyl cellulose, polyvinyl morpholinone, polymers and copolymers of vinyl sulfonic acid, polyacrylates, polyacrylamides, polyvinyl pyridine and the like. Other suitable polymers include hydrolyzed acrylonitrile grafted starch, acrylic acid grafted starch, and isobutylene maleic anhydride copolymers, and mixtures thereof. The hydrogel polymers are preferably lightly cross-linked to impart desired levels of water insolubility to the material. Crosslinking may, for example, be by irradiation or by covalent, ionic, Van der Waals, or hydrogen bonding. Suitable materials are available from various commercial vendors, such as Dow Chemical Company, Hoechst Celanese Corporation, Allied-Colloid, and Stockhausen. Typically, the high-absorbency material is capable of absorbing at least about 15 times its weight in water, and preferably is capable of absorbing at least between about 25 and about 100 times its weight in water.

The particulate material **10**, such as high absorbency superabsorbent particles, may have regular shapes or irregular shapes, such as elongated forms. For example, the particulate material **10** may be configured in the form of granules, flakes, fibers, or the like. The particulate material **10** typically measure from about 50 to about 1000 micrometers in size, preferably measure from about 100 to about 800 micrometers, and more preferably measure from about 200 to about 600 micrometers in size to provide improved processability through the method of the present invention.

With reference to **FIGURE 1**, a representative method of the present invention is configured to form a substantially uniform distribution of particulate material **10**, such as particles of a superabsorbent polymer material (SAM), within the cross direction of a fibrous web **42**, such as a fibrous web **42** comprising woodpulp fluff fibers **40**. A conveying means **15**, such as a mechanism composed of the particle feeder device **14** and the conveying blower **16**, provides a gas entrained supply stream **18** of the particulate material **10** through a delivery conduit **30** and delivery nozzle **36** into a web forming chamber **32**.

The fiberizing means **33**, such as the hammermill **34** provides a flow of a selected fibrous material **40**, such as woodpulp fluff fibers, into the web forming chamber **32**. A directing means **35**, such as the delivery nozzle **36**, controls the flow (intermittent or

otherwise) of the particulate material **10** from the delivery conduit **30** and through the delivery nozzle **36** into web forming chamber **32**, and a foraminous forming layer **38** is moveable and disposed within the web forming chamber **32** to receive the fluff fibers **40** and the particulate material **10** thereon to form the fibrous web **42**. The fibrous web **42** may include distinctive, zoned regions having selected, different amounts of particulate material **10** therein as disclosed in U.S. Pat. No. 5,102,585 issued to Pieper et al. on April 7, 1992 and U.S. Pat. No. 5,028,224 issued to Pieper et al. on July 2, 1991, incorporated herein by reference. The method of the present invention can advantageously operate at high speeds.

The feeder device **14** includes a particulate regulating means **19** for providing a selected mass flow rate of the particulate material **10**, such as high absorbency particles composed of superabsorbent hydrogel polymer, into a conveying gas stream **46** provided by the conveying blower **16**. It should be readily understood that the amount of particulate material **10** delivered into the conveying gas stream **46** is dependent upon the forming rate of the fibrous web **42** and the weight percent of the particulate material **10** desired to be contained within the fibrous web **42**. In the illustrated embodiment, the particulate regulating means **19** is constructed and configured to provide a particulate mass flow rate which is within the range of about 6 - about 400 gm/sec. Various types of feeder mechanisms, such as a feeder device **14**, may be employed with the present invention. This feeder device **14** can thereby help control the delivery of the desired amounts of particulate material **10** into the fibrous web **42**. In the shown embodiment, the feeder device **14** may be a LWF3-35 feeder manufactured by the K-tron Corp., a company located in Pitman, N.J. Other equivalent feeder devices **14** may also be employed with the present invention.

Various types of commercially available blower devices may be employed with the present invention. In the shown embodiment, conveying blower **16** may be a VB-019 blower manufactured by Spencer Turbine, a company located in Windsor, Conn.

In particular embodiments of the present invention, the conveying blower **16** is configured to supply a conveying gas flow velocity of not less than about 5 m/sec (about 1000 ft/min), and preferably provides a gas velocity of not less than about 9 m/sec (about 1800 ft/min). In other embodiments of the present invention, the conveying blower **16** is configured to provide a gas velocity in the conveying gas stream **46** of not more than about 35 m/sec (about 7000 ft/min), and preferably provides a velocity of not more than

about 45 m/sec (about 8500 ft/min) to provide improved performance. A suitable conveying conduit **17** is employed to transport the particle/gas mixture **18** composed of the particulate material **10** entrained in the moving stream of the conveying gas **46**.

The proper flow of the conveying gas **46** is dependent on the particulate material **10** being conveyed. In addition to the velocity ranges given, it is desirable to maintain the "solids loading ratio" (mass flow rate of material divided by the mass flow rate of conveying gas) below about 5. Preferably, the solids loading ratio is maintained below about 3. At these ratios, the resultant two-phase flow is typically classified as the "lean phase". The lean phase flow is desirable to minimize short-term weight variability.

**FIGURE 1** provides a detailed illustration of the web forming chamber **32**. The web forming chamber **32** includes a fiber delivery means **39**, such as the fiberizer hammermill **34**, which provides a flow of the fibrous material **40** within the web forming chamber **32**. The foraminous forming layer **38**, which is located in the web forming chamber **32** and movable therein, is configured to receive a deposit of the fibrous material **40** thereon. Piping means, such as the delivery conduit **30**, and one or more of the delivery nozzles **36**, supply a flow of dispersed bodies of particulate material **10**, such as the superabsorbent polymer particles. This flow of particulate material **10** enters the web forming chambers **32** and intermixes with the flow of the fibrous material **40** therein. The flow regulating means **20**, such as the flow angle adjuster **126**, controls the flow vector of the delivery gas stream **28** of the particulate material **10** within the fibrous material **40** deposited onto the forming layer **38** to form the fibrous web **42**.

The web forming chamber **32** includes the side walls **115** and the end walls **116** and **118** which are constructed and arranged to define a generally enclosed volume. The end walls **116** and **118** have suitable entrance and exit openings formed therethrough to allow the entry of the forming layer **38** and the removal of the air-formed fibrous web **42** from the web forming chamber **32**.

The hammermill **34** may comprise any one of a number of types of conventional fiberizing devices. The sheets of selected fibrous material **40** are typically fed into the hammermill **34**, and are disintegrated into a plurality of the individual fibers **40** which are injected or otherwise introduced into the web forming chamber **32**. The fibers **40** are typically composed of absorbent, woodpulp fibers commonly referred to as fluff. The fibers **40** may also be composed of staple fibers, polymeric fibers, cellulosic fibers and

mixtures thereof, as well as mixtures of absorbent fibers with generally hydrophobic fibers. The fibrous material **40** may optionally be treated to impart desired levels of hydrophilicity, employing techniques well known in the art.

The web forming chamber **32** of the present invention may further include vacuum means **132**, such as a conventional blower mechanism, for creating a selected pressure differential through the web forming chamber **32** and past the forming layer **38**. The vacuum means **132** is typically located underneath the forming layer **38** to create an air flow through the web forming chamber **32** which is generally directed from the hammermill **34** and past the forming layer **38**. This airflow helps to direct and control the deposit of the fibers **40** and the particulate material **10** onto the forming layer **38**.

The forming layer **38**, for example, may comprise a foraminous forming screen configured as an endless belt which moves about the support rollers **162** and **164**. A suitable driving means, such as an electric motor **166**, is operably connected to move the forming layer **38** through the web forming chamber **32** at a selected speed along the machine direction **168**. The fibers **40** and the particulate material **10** deposit onto the portion of the forming layer **38** within the web forming chamber **32** to form the fibrous web **42**, which eventually develops into an absorbent body **240** within an absorbent article **210**. Since forming layer **38** moves generally from the end wall **116** toward the exit opening through the end wall **118**, the depth or thickness of the fibrous web **42** on any particular section of the forming layer **38** gradually increases as that section of the forming layer **38** traverses through the web forming chamber **32**. The fiber deposition rate onto the forming layer **38** and the movement speed of the forming layer **38** can be suitably adjusted to control the finally formed thickness of the air-formed fibrous web **42**.

In another aspect of the present invention, the forming layer **38** comprises a foraminous forming screen carrier on an outer circumferential surface of a rotatable drum. A suitable driving means, such as a motor, rotates the drum to move the forming layer **38** through the web forming chamber **32**.

The delivery nozzles **37** currently being used in the industry are typically circular structures as shown in **FIGURE 3**. As the center of the delivery nozzle **37**, as shown along the x-x line in **FIGURE 3**, is larger than the side portion of the delivery nozzle **37**, as shown along line y-y in **FIGURE 3**, more particulate material **10** is deposited on the corresponding central region of the forming layer **38**. (See **FIGURE 4**.) As expected, the

corresponding outer portion of the forming layer **38** receives lower amounts of the particulate material **10**. This non-uniform distribution of the particulate material **10** is shown in a swollen and stained state in **FIGURE 5**. The absorbent body **240** of the absorbent article **210** is caused to swell by placing the absorbent body **240** in a solution of 0.9% by weight of sodium chloride in water. In addition, the saline solution contains about 0.004 grams per liter of FD&C Blue #1 dye or, in the alternative, enough of the dye to provide the desired level of contrast. The particulate material **10** absorbs a greater amount of the saline solution, and therefore a greater amount of the dye than does the fibrous web **42**. As such, the particulate material **10** is a dark blue color as compared to the much lighter blue tint of the fibrous web **42**. The particulate material **10** is the darkened lump or bell-curve shaped mass. This non-uniform distribution of the particulate material **10** results in poorer absorbency performance of the absorbent article **210**. In addition, as the particulate material **10** swells upon the absorption of fluid, the absorbent body **240** of the absorbent article **210** distorts and can become uncomfortable.

It is the geometric shape of the delivery nozzle **36** of the present invention that provides the substantially uniform distribution of the particulate material **10** in the cross direction of the fibrous web **42**. One such delivery nozzle **36** that provides a substantially uniform distribution of the particulate material **10** is shown in **FIGURES 6, 7,** and **8**. The delivery nozzle **36a** is circular in shape. Side portions of the delivery nozzle **36a** have been removed, forming a pair of gaps **48** and **50** in the end edge **52**. The gaps **48** and **50** may be semi-circular as shown in **FIGURES 6** and **10** or triangular shaped as shown in **FIGURE 8** or any variation of these designs. The gaps **48** and **50** allow the particulate material **10** to spread out within the web forming chamber **32**, thereby avoiding an non-uniform distribution of particulate material **10**. The delivery nozzle **36a** containing the gaps **48** and **50** may also be oval in shape, having the a-a line parallel to the forming layer **38** as shown in **FIGURE 9**. The resulting substantially uniform distribution of the particulate material **10** resulting from a circular shaped delivery nozzle **36a** including gaps **48** and **50** shaped like half circles is shown in a swollen and stained stated in **FIGURE 11**. The particulate material **10** is the darkened oval shaped mass. The end edge **52** of the delivery nozzle **36a** may be flared out from the delivery conduit **30** as shown in **FIGURE 10**.

Another embodiment of the delivery nozzle **36b** that provides a substantially uniform distribution of the particulate material **10** is shown in **FIGURES 12** and **13**. The delivery nozzle **36b** is oval in shape, having the a'-a' line of the delivery nozzle **36b**

parallel to the forming layer **38**. The end edge **52** of the delivery nozzle **36b** may flare out from the delivery conduit **30**. (See **FIGURE 13**.) The flaring of the end edge **52** further promotes the distribution of the particulate material **10** within the web forming chamber **32**. The resulting substantially uniform distribution of the particulate material **10** resulting from an oval shaped delivery nozzle **36b** including a flared end edge **52** is shown in a swollen and stained state in **FIGURE 14**. The particulate material **10** is the darkened oval shaped mass.

Another embodiment of the delivery nozzle **36c** that provides a substantially uniform distribution of the particulate material **10** is shown in **FIGURES 15, 16, 17,** and **18**. The delivery nozzle **36c** is circular in shape. A wedge member **54**, as shown in **FIGURE 16**, is positioned within the delivery nozzle **36c** as shown in **FIGURES 15** and **16**. The wedge member **54** has front face **56** which faces into the web forming chamber **32** and a rear portion **58** that is positioned within the delivery nozzle **36c** and may extend into the delivery conduit **30**. The wedge member **54** may be rotated through 180° as shown in **FIGURES 17** and **18**, and any position along the 180° rotation. The rear portion **58** may have a variety of shapes in addition to the shape shown in **FIGURE 16**. The wedge member **54** forces the particulate material **10** toward the sides of the delivery nozzle **36c**, resulting in a substantially uniform distribution of particulate material **10**, as shown in a swollen and stained state in **FIGURE 20**. The particulate material **10** is the darkened oval shaped mass. The end edge **52** of the delivery nozzle **36c** may be flared out from the delivery conduit **30** as shown in **FIGURE 19**.

The present invention may include a single delivery nozzle **36** or may include a multiple delivery nozzle **36** system.

Referring again to **FIGURE 1**, the delivery nozzle **36** may protrude into the web forming chamber **32** a predetermined distance to adjust the distribution of particulate material **10** through the thickness of the fibrous web **42**. A larger amount of protrusion can, for example, reduce the amount of particulate material **10** deposited near the forming layer side of the fibrous web **42**. This design results in a non-uniform distribution of particulate material **10** in the z-direction (throughout the thickness) of the fibrous web **42**. As shown in **FIGURE 2**, the delivery nozzle **36** may end flush with the wall **116** of the web forming chamber **32**. Such a design results in a more substantially uniform distribution of particulate material **10** in the z-direction of the fibrous web **42**.

The delivery nozzle **36** can be suitably adjusted to a nonparallel angle slanted toward or away from the forming layer **38**. If the delivery nozzle **36** is angled toward the forming layer **38**, relatively more the particulate material **10** can be deposited near the forming layer side of the fibrous web **42**. If the delivery nozzle **36** is angled away from the forming layer **38**, relatively more the particulate material **10** can be deposited near the upper, free surface side of the fibrous web **42**. For example, in a particular aspect of the present invention, the delivery nozzle **36** is constructed and arranged to be pivotable within a range of approximately plus (upwardly) 45° to minus (downwardly) 60°, relative to a plane positioned generally parallel to the forming layer **38**. Preferably, the delivery nozzle **36** is pivotable within the range of about plus 10° and minus 45° relative to such plane, respectively away or toward the forming layer **38**.

The entry angle of the moving particulate material **10**, such as superabsorbent particles can be adjusted by selectively orienting the delivery nozzle **36**, and velocities of the particulate material **10** can be appropriately regulated to impart desired, predetermined trajectories to the particulate material **10**. As a result, the particulate material **10** can travel different horizontal distances through the web forming chamber **32** in a direction generally parallel to the machine direction of the apparatus. In the illustrated embodiment, the particulate material **10** move along with the movement of the formed fibrous web **42**, but in alternative embodiments, the method can be configured to move the particulate material **10** counter to the movement of the fibrous web **42**. The difference in horizontal distances can cause differing amounts and/or differing weight percent concentrations of the particulate material **10** to be selectively placed at various desired levels through the thickness dimension of the fibrous web **42**.

Particular aspects of the present invention can include combinations of the various, different types systems for delivering the particulate material **10** into the web forming chamber **32**.

With reference to **FIGURE 21**, an integral absorbent garment article **210**, such as a disposable diaper, generally delimits a front waistband panel-section **212**, a rear waistband panel-section **214**, and an intermediate section **216** which interconnects the front and rear waistband sections. The absorbent article **210** comprises a substantially fluid impermeable backsheet layer **220**, a liquid permeable topsheet layer **230** positioned in facing relation with the backsheet layer **220**, and an absorbent body **240** is located

between the backsheet layer **220** and the topsheet layer **230**. For reference purposes, the absorbent article **210** has a longitudinal direction **142**, a cross-direction **144** and a longitudinal centerline **146**.

The marginal portions of the absorbent article **210**, such as the marginal sections of the backsheet **220**, may extend past the terminal edges of the absorbent body **240** which includes the fibrous web **242**. In the illustrated embodiment, for example, backsheet **220** extends outwardly beyond the terminal marginal edges of the absorbent body **240** to form the garment side margins **226** and **228** and the garment end margins **222** and **224**. The topsheet **230** is generally coextensive with the backsheet **220**, but may optionally cover an area which is larger or smaller than the area of the backsheet **220**, as desired.

The absorbent article **210** may be of various suitable shapes. For example, the absorbent article **210** may have an overall rectangular shape, T-shape or an approximately hour-glass shape. In the shown embodiment, the absorbent article **210** has a generally I-shape.

The various components of the absorbent article **210** are integrally assembled together employing various types of suitable attachment means, such as adhesive, ultrasonic bonds, thermal bonds, and the like, and combinations thereof. In the shown embodiment, for example, the topsheet **230** and the backsheet **220** are assembled to each other and to the absorbent body **240** with lines and patterns of adhesive, such as a hot melt, pressure-sensitive adhesive. Similarly, other absorbent article **210** components, such as the elastic members **260**, **262**, **264**, and **266** and the fastening members **236**, may be assembled into the absorbent article **210** by employing the above-identified attachment mechanisms.

The illustrated embodiment of the absorbent article **210** includes the ear portions **248**, which extend laterally along the absorbent article cross-direction **144** and are positioned at least at one waistband section of the absorbent article **210**, preferably at the rear waistband section **214**. The ear portions **248** may also be located at the front waistband section **212** of the absorbent article **210**. The ear portions **248** may be integral with backsheet layer **220**, or may comprise separate sections, which are composed of the same or different material than the backsheet layer **220** and are suitably assembled and attached to the backsheet layer **220**. The ear sections **248** typically provide extensions of

the absorbent article waistband suitable for completely encircling the waist of the wearer during use.

The fastening means **236**, such as adhesive tapes, are employed to secure the absorbent article **210** on a wearer. Alternatively, other fastening means, such as buttons, pins, snaps, hook-and-loop fasteners, mushroom-and-loop fasteners, or the like, may be employed.

To provide an improved fit and to help reduce leakage of body exudates from absorbent article **210**, the side margins **226** and **228** and the end margins **222** and **224** may be elasticized with the suitable elastic members **260** and **262**, such as single or multiple strands of elastic. The elastic members **260** and **262** may be composed of natural or synthetic rubber or other elastomeric materials, and may optionally be heat-shrinkable or heat-elasticizable. The elastic members **260** and **262** are constructed to operably gather and shirr the side margins **226** and **228** to provide elasticized leg bands which can closely fit around the legs of the wearer to reduce leakage and provide improved comfort and appearance. Similarly, the waist elastic members **264** and **266** can be employed to elasticize the end margins **222** and **224** to provide elasticized waistbands. The waist elastics **264** and **266** are configured to operably gather and shirr the waistband sections to provide a resilient, comfortably close fit around the waist of the wearer.

The backsheet layer **220** is composed of a substantially liquid impermeable material, which is also gas impermeable but may optionally be gas/vapor permeable. In the illustrated embodiment, the backsheet layer **220** is substantially impermeable to water and water vapor. An example of a suitable backsheet material is a polymer film composed of polyethylene, polypropylene, or the like. Typically, the polymer film has a thickness within the range of about 0.0004 - about 0.002 inch (0.0010 - 0.0051 cm). The backsheet layer **220** may alternatively be composed of a nonwoven fibrous web constructed to provide the desired levels of fluid impermeability. For example, a nonwoven web composed of spunbonded or meltblown polymer fibers may be selectively treated with a water repellent coating, or laminated with a fluid impermeable, polymer film.

In alternative embodiments of the present invention, the backsheet layer **220** may comprise a nonwoven web composed of a plurality of randomly deposited hydrophobic thermoplastic meltblown fibers which are sufficiently bonded or otherwise connected to one another to provide a substantially vapor impermeable and substantially liquid

impermeable web. The backsheet layer **220** may also comprise a vapor permeable nonwoven layer which has been partially coated or otherwise configured to provide liquid impermeability only in selected areas, leaving the remaining areas vapor permeable.

The topsheet **230** is typically composed of a liquid permeable, substantially hydrophobic fibrous material, such as a spunbonded web composed of synthetic polymer filaments. Alternatively, the topsheet **230** may comprise a meltblown web or a bonded-carded-web composed of synthetic polymer filaments. Suitable synthetic polymers include, for example, polyethylene, polypropylene and polyesters. In a particular aspect of the invention, the polymer filaments have a denier within the range of about 1.5 to about 7 d and preferably have a denier within the range of about 1.5 to about 3 d to provide improved performance. The filaments are arranged to form a layer having a basis weight within the range of about 8 to about 34 gm/m2 (gsm), and preferably are arranged to have a basis weight of about 27 gsm.

The topsheet **230** may optionally be treated with surfactants to adjust its degree of hydrophobicity and wettability. It can also be selectively embossed or apertured with discrete slits or holes **232** extending therethrough.

The absorbent body **240** comprises an integral mass of hydrophilic material which is typically configured to form a fibrous absorbent pad layer. The hydrophilic fibers can, for example, be composed of a fibrous cellulosic material commonly referred to as woodpulp fluff, and can be air-formed to form an integral fibrous pad. Other fibers, such as cotton and synthetic polymer fibers, may also be employed to form the pad. Conventional absorbent pads can have a density ranging from about 0.05 to about 0.50 grams/cc, preferably 0.08 to about 0.3 grams/cc, more preferably 0.12 to about 0.20 grams/cc, and are sufficiently flexible to readily conform to the body shape of the wearer. In particular arrangements, the fibrous material comprising the absorbent body **240** may be non-uniformly distributed over the pad length and width. For example, see U.S. Pat. No. 4,585,448, "Disposable Garment Having High-Absorbency Area", issued April 29, 1986 to K. Enloe.

To increase the absorbent capacity of the absorbent body **240**, it has been desirable to add quantities of relatively high-absorbency material to the fibers comprising the absorbent body **240**. Such high-absorbency materials are capable of holding, on a weight basis, at least about 15 parts of water per part of high-absorbency material.

Preferably, the high absorbency material is capable of holding at least about 100 parts of water per part of high-absorbency material.

The absorbent body **240** should include an effective amount of the high-absorbency material to operably enhance the absorptive capacity of the absorbent body **240**. For example, the absorbent body **240** can contain between about 5 to about 95 weight percent high-absorbency material, and preferably includes between about 10 to about 50 weight percent of the high-absorbency material to provide more efficient performance.

The high-absorbency material has typically been distributed or otherwise incorporated into the absorbent body **240** by employing various techniques. For example, the high-absorbency material can be incorporated into a separate carrier sheet which is layered with a body of air-formed cellulosic fibers. Alternatively, the high-absorbency material may be substantially uniformly distributed in the z-direction and mixed within the mass of fibers comprising the absorbent body **240**. The material can also be non-uniformly distributed in the z-direction among the fibers to form, for example, a generally continuous gradient with either an increasing or decreasing concentration of high-absorbency material, as determined by observing the concentration moving from the body-side of the absorbent body **240** toward the outer-side of the absorbent body **240**. The high-absorbency material may also be substantially unmixed with the fibrous material of the absorbent body **240**, and may comprise one or more discrete layers or strips selectively segregated from the fibrous material.

Optionally, a substantially hydrophilic tissue wrap **242** may be employed to help maintain the integrity of the air-formed fibrous structure of the absorbent body **240**. The tissue wrap **242** is typically placed about the absorbent body **240** over at least the two major facing surfaces thereof, and composed of an absorbent cellulosic material, such as creped wadding or a high wet-strength tissue.

In a particular aspect of the present invention, the absorbent body **240** has the structural configuration of a concurrently air-formed mixture of hydrophilic fibers and particulate material **10**. The fibers and particulate material **10** are concurrently formed into a substantially integral web layer while the fibers and particulate material **10** are intermingled with each other. In such structure, the particulate material **10** is not substantially isolated in a discrete superabsorbent layer. The resultant absorbent body

**240** can include a distinctive, selectively varied distribution of the particulate material **10** along the longitudinal length dimension **142** of the absorbent body **240**. For example, the average weight percentage of particulate material **10** can be non-uniformly distributed along said length dimension.

The intermixed configuration of the particulate material **10** and fibrous material is desirable because it can provide an advantageous combination of capillarity, interfiber void volume and total absorbent capacity. The fibrous material contributes to the capillarity and interfiber void volume, while the particulate material **10** contribute to the total absorbent capacity. The fiber capillarity helps provide a rapid movement and wicking of liquid through the absorbent body **240** and the interfiber void volume helps provide a rapid rate of liquid uptake into the absorbent body **240**. In addition, the intermingled configuration of the particulate material **10** and fibrous material helps improve the mechanical integrity of the total structure.

The method of the present invention for forming a substantially uniform distribution of particulate material **10** in the cross-machine direction within a fibrous web **42**, comprises the steps of:

(a) providing a gas entrained supply stream **18** of the particulate material **10**;

(b) transferring a selected quantity of the particulate material **10** into a delivery gas stream **28** to provide a flow of the particulate material **10** through a delivery conduit **30** and a delivery nozzle **36b**, including an end edge 52 and having an oval shape, into a web forming chamber **32**;

(c) providing a flow of a selected fibrous material **40** into the web forming chamber **32**; and,

(d) receiving the fibrous material **40** and the particulate material **10** on a foraminous forming layer **38** located within the web forming chamber **32** to produce a fibrous web **42** which includes a substantially uniform distribution of the particulate material **10**.

The method may further comprise the step of positioning the delivery nozzle **36b** to provide a substantially uniform distribution of the particulate material **10** in the cross direction of the fibrous web. The end edge **52** of the delivery nozzle **36b** may flare out from the delivery conduit **30**. The method may further comprise the step of positioning the delivery nozzle **36b** to provide a substantially uniform distribution of the particulate material **10** in the cross direction **144** of the fibrous web **42**. The providing step may

include the steps of generating a stream **46** of conveying gas for entraining the particulate material **10** and regulating a flow of the conveying gas **46** to provide a gas flow velocity within the range of about 5m/sec to about 45 m/sec. The method may further comprise the steps of providing the delivery gas stream **28** and regulating a flow of the delivery gas stream **28** to provide a velocity of gas flow within the range of about 5m/sec to about 45 m/sec. The method may further comprise a step of providing a selected, regulated mass flow rate of the particulate material **10** within the supply stream **18**.

The method may further comprise the step of controlling the flow of the particulate material **10** from the delivery conduit **30** and the delivery nozzle **36b** into the forming chamber **32**. The transferring step may comprise the steps of delivering a controlled quantity of the particulate material **10** to the delivery conduit **30** and providing the delivery stream **28** of gas at a selected velocity to move the particulate material **10** through the delivery conduit **30**. The method may further comprise a step of directing a substantially continuous stream of particulate material **10** into the web forming chamber **32**. The selective transferring step may comprise the steps of directing a first particulate material **10** into the web forming chamber **32** with a first transferring means; and, directing at least a second particulate material **10** into the web forming chamber **32** with a second transferring means. In the alternative, the method may further comprise a step of directing an intermittent stream of particulate material **10** into the web forming chamber **32**.

Another embodiment of the method of the present for forming a substantially uniform distribution of particulate material **10** in the cross-machine direction within a fibrous web **42**, comprising the steps of:

(a) providing a gas entrained supply stream **18** of the particulate material **10**;

(b) transferring a selected quantity of the particulate material **10** into a delivery gas stream **28** to provide a flow of the particulate material **10** through a delivery conduit **30** and a delivery nozzle **36a**, including an end edge **52** and having a circular shape including gaps **48** and **50** on the end edge **52** facing into a web forming chamber **32**, into a web forming chamber **32**;

(c) providing a flow of a selected fibrous material **40** into the web forming chamber **32**; and,

(d) receiving the fibrous material **40** and the particulate material **10** on a foraminous forming layer **38** located within the forming chamber **32** to

produce a fibrous web **42** which includes a substantially uniform distribution of the particulate material **10**.

The method may further comprise the step of positioning the delivery nozzle **36a** to provide a substantially uniform distribution of the particulate material **10** in the cross direction **144** of the fibrous web **42**. The end edge **52** of the delivery nozzle **36a** may flare out from the delivery conduit **30**. The method may further comprise the step of positioning the delivery nozzle **36a** to provide a substantially uniform distribution of the particulate material **10** in the cross direction **144** of the fibrous web **42**. The gaps **48** and **50** in the end edge **52** of the delivery nozzle **36a** may be semi-circular in shape or triangular in shape. The providing step may include the steps of generating a stream **46** of conveying gas for entraining the particulate material **10** and regulating a flow of the conveying gas **46** to provide a gas flow velocity within the range of about 5m/sec to about 45 m/sec. The method may further comprise steps of providing the delivery gas stream **28** and regulating a flow of the delivery gas stream **28** to provide a velocity of gas flow within the range of about 5m/sec to about 45 m/sec. The method may further comprise a step of providing a selected, regulated mass flow rate of the particulate material **10** within the supply stream **18**. The method may further comprise the step of controlling the flow of the particulate material **10** from the delivery conduit **30** and the delivery nozzle **36a** into the forming chamber **32**.

The transferring step may comprise steps of delivering a controlled quantity of the particulate material **10** to the delivery conduit **30** and providing the delivery stream **28** of gas at a selected velocity to move the particulate material **10** through the delivery conduit **30**. The method may further comprise a step of directing a substantially continuous stream of particulate material **10** into the web forming chamber **32**. In the alternative, the method may further comprise a step of directing an intermittent stream of particulate material **10** into the web forming chamber **32**.

The selective transferring step comprises the steps of directing a first particulate material **10** into the web forming chamber **32** with a first transferring means and directing at least a second particulate material **10** into the web forming chamber **32** with a second transferring means.

Another embodiment of the method of the present invention for forming a substantially uniform distribution of particulate material **10** in the cross-machine direction **144** within a fibrous web **42**, comprising the steps of:

(a) providing a gas entrained supply stream **18** of the particulate material **10**;

(b) transferring a selected quantity of the particulate material **10** into a delivery gas stream **28** to provide a flow of the particulate material **10** through a delivery conduit **30** and a delivery nozzle **36b**, including an end edge **52** and having a oval shape including gaps **48** and **50** on the end edge **52** facing into a web forming chamber **32**, into a web forming chamber **32**;

(c) providing a flow of a selected fibrous material **40** into the web forming chamber **32**; and,

(d) receiving the fibrous material **40** and the particulate material **10** on a foraminous forming layer **38** located within the forming chamber **32** to produce a fibrous web **42** which includes a substantially uniform distribution of the particulate material **10**.

The method may further comprise the step of positioning the delivery nozzle **36b** to provide a substantially uniform distribution of the particulate material **10** in the cross direction **144** of the fibrous web **42**. The end edge **52** of the delivery nozzle **36b** may flare out from the delivery conduit **30**. The method may further comprise the step of positioning the delivery nozzle **36b** to provide a substantially uniform distribution of the particulate material **10** in the cross direction **144** of the fibrous web **42**. The gaps **48** and **50** in the end edge **52** of the delivery nozzle **36b** may be semi-circular in shape or triangular in shape. The providing step may include the steps of generating a stream **46** of conveying gas for entraining the particulate material **10** and regulating a flow of the conveying gas to provide a gas flow velocity within the range of about 5m/sec to about 45 m/sec. The method may further comprise steps of providing the delivery gas stream **28** and regulating a flow of the delivery gas stream **28** to provide a velocity of gas flow within the range of about 5m/sec to about 45 m/sec. The method may further comprise a step of providing a selected, regulated mass flow rate of the particulate material **10** within the supply stream **18**. The method may further comprise the step of controlling the flow of the particulate material **10** from the delivery conduit **30** and the delivery nozzle **36b** into the forming chamber **32**.

The transferring step may comprises steps of delivering a controlled quantity of the particulate material **10** to the delivery conduit **30** and providing the delivery stream **28** of

gas at a selected velocity to move the particulate material **10** through the delivery conduit **30**. The method may further comprise a step of directing a substantially continuous stream of particulate material **10** into the web forming chamber **32**. In the alternative, the method may further comprise a step of directing an intermittent stream of particulate material **10** into the web forming chamber **32**.

The selective transferring step comprises the steps of directing a first particulate material **10** into the web forming chamber **32** with a first transferring means and directing at least a second particulate material **10** into the web forming chamber **32** with a second transferring means.

Another embodiment of the method of the present invention for forming a substantially uniform distribution of particulate material **10** in the cross-machine direction **144** within a fibrous web **42**, comprising the steps of:

(a) providing a gas entrained supply stream **18** of the particulate material **10**;

(b) transferring a selected quantity of the particulate material **10** into a delivery gas stream **28** to provide a flow of the particulate material **10** through a delivery conduit **30** and a delivery nozzle **36c**, including an end edge **52** and a wedge member **54** wherein the delivery nozzle **36c** is circular shaped, into a web forming chamber **32**;

(c) providing a flow of a selected fibrous material **40** into the web forming chamber **32**; and,

(d) receiving the fibrous material **40** and the particulate material **10** on a foraminous forming layer **38** located within the forming chamber **32** to produce a fibrous web **42** which includes a substantially uniform distribution of the particulate material **10**.

The method may further comprise the step of positioning the delivery nozzle **36** to provide a substantially uniform distribution of the particulate material **10** in the cross direction of the fibrous web. The end edge **52** of the delivery nozzle **36c** may flare out from the delivery conduit **30**. The method may further comprise the step of positioning the delivery nozzle **36** to provide a substantially uniform distribution of the particulate material **10** in the cross direction **144** of the fibrous web **42**. The providing step may include the steps of generating a stream **46** of conveying gas for entraining the particulate material **10** and regulating a flow of the conveying gas **46** to provide a gas flow velocity within the range of about 5m/sec to about 45 m/sec. The method may further comprise the steps of

providing the delivery gas stream **28** and regulating a flow of the delivery gas stream **28** to provide a velocity of gas flow within the range of about 5m/sec to about 45 m/sec. The method may further comprise a step of providing a selected, regulated mass flow rate of the particulate material **10** within the supply stream **18**.

The method may further comprise the step of controlling the flow of the particulate material **10** from the delivery conduit **30** and the delivery nozzle **36c** into the forming chamber **32**. The transferring step may comprise the steps of delivering a controlled quantity of the particulate material **10** to the delivery conduit **30** and providing the delivery stream **28** of gas at a selected velocity to move the particulate material **10** through the delivery conduit **30**. The method may further comprise a step of directing a substantially continuous stream of particulate material **10** into the web forming chamber **32**. In the alternative, the method may further comprise a step of directing an intermittent stream of particulate material **10** into the web forming chamber **32**. The selective transferring step may comprise the steps of directing a first particulate material **10** into the web forming chamber **32** with a first transferring means; and, directing at least a second particulate material **10** into the web forming chamber **32** with a second transferring means.

Having thus described the invention in rather full detail, it will be readily apparent to a person having ordinary skill in the art that various changes and modifications can be made without departing from the spirit of the invention. All of such changes and modifications are contemplated as being within the scope of the present invention, as defined by the subjoined claims.

**WE CLAIM:**

**1.** A method for forming a substantially uniform distribution of particulate material in the cross-machine direction within a fibrous web, comprising the steps of:

(a) providing a gas entrained supply stream of said particulate material;

(b) transferring a selected quantity of said particulate material into a delivery gas stream to provide a flow of said particulate material through a delivery conduit and a delivery nozzle, including an end edge and having an oval shape, into a web forming chamber;

(c) providing a flow of a selected fibrous material into said web forming chamber; and,

(d) receiving said fibrous material and said particulate material on a foraminous forming layer located within said web forming chamber to produce said fibrous web which includes a substantially uniform distribution of said particulate material.

**2.** The method as recited in Claim 1, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**3.** The method as recited in Claim 1, wherein said end edge of said delivery nozzle flares out from the delivery conduit.

**4.** The method as recited in Claim 3, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**5.** The method as recited in Claim 1, wherein said providing step (a) includes steps of:

generating a stream of conveying gas for entraining said particulate material; and,

regulating a flow of said conveying gas to provide a gas flow velocity within the range of about 5m/sec to about 45 m/sec.

**6.** The method as recited in Claim 5, further comprising steps of:

providing said delivery gas stream; and,

regulating a flow of said delivery gas stream to provide a velocity of gas flow within the range of about 5m/sec to about 45 m/sec.

**7.** The method as recited in Claim 6, further comprising a step of providing a selected, regulated mass flow rate of said particulate material within said supply stream.

**8.** The method as recited in Claim 1, further comprising the step of controlling said flow of said particulate material from said delivery conduit and said delivery nozzle into said web forming chamber.

**9.** The method as recited in Claim 1, wherein said transferring step (b) comprises steps of:

delivering a controlled quantity of said particulate material to said delivery conduit; and,

providing said delivery stream of gas at a selected velocity to move said particulate material through said delivery conduit.

**10.** The method as recited in Claim 9, further comprising a step of directing a substantially continuous stream of particulate material into said web forming chamber.

**11.** The method as recited in Claim 1, further comprising a step of directing a substantially continuous stream of particulate material into said web forming chamber.

**12.** The method as recited in Claim 1, further comprising the step of directing an intermittent stream of particulate material into said web forming chamber.

**13.** The method as recited in Claim 1, wherein said selective transferring step (b) comprises the steps of:

directing a first particulate material into said web forming chamber with a first transferring means; and,

directing at least a second particulate material into said web forming chamber with a second transferring means.

**14.** A method as recited in Claim 13, further comprising the step of directing a substantially continuous stream of particulate material into said web forming chamber.

**15.** A method for forming a substantially uniform distribution of particulate material in the cross-machine direction within a fibrous web, comprising the steps of:

(a) providing a gas entrained supply stream of said particulate material;

(b) transferring a selected quantity of said particulate material into a delivery gas stream to provide a flow of said particulate material through a delivery conduit and a delivery nozzle, including an end edge and having a circular shape including gaps on the end edge facing into a web forming chamber, into said web forming chamber;

(c) providing a flow of a selected fibrous material into said web forming chamber; and,

(d) receiving said fibrous material and said particulate material on a foraminous forming layer located within said forming chamber to produce said fibrous web which includes a substantially uniform distribution of said particulate material.

**16.** The method as recited in Claim 15, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**17.** The method as recited in Claim 15, wherein said end edge of said delivery nozzle flares out from said delivery conduit.

**18.** The method as recited in Claim 17, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**19.** The method as recited in Claim 15, wherein said gaps in said end edge of said delivery nozzle are semi-circular in shape.

**20.** The method as recited in Claim 19, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**21.** The method as recited in Claim 20, wherein said end edge of said delivery nozzle flares out from said delivery conduit.

**22.** The method as recited in Claim 21, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**23.** The method as recited in Claim 15, wherein said gaps in said end edge of said delivery nozzle are triangular in shape.

**24.** The method as recited in Claim 23, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**25.** The method as recited in Claim 24, wherein said end edge of said delivery nozzle flares out from the delivery conduit.

**26.** The method as recited in Claim 25, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**27.** The method as recited in Claim 15, wherein said providing step (a) includes steps of:

generating a stream of conveying gas for entraining said particulate material; and,

regulating a flow of said conveying gas to provide a gas flow velocity within the range of about 5m/sec to about 45 m/sec.

**28.** The method as recited in Claim 27, further comprising steps of:

providing said delivery gas stream; and,

regulating a flow of said delivery gas stream to provide a velocity of gas flow within the range of about 5m/sec to about 45 m/sec.

**29.** The method as recited in Claim 28, further comprising a step of providing a selected, regulated mass flow rate of said particulate material within said supply stream.

**30.** The method as recited in Claim 15, further comprising the step of controlling said flow of said particulate material from said delivery conduit and said delivery nozzle into said forming chamber.

**31.** The method as recited in Claim 15, wherein said transferring step (b) comprises steps of:

delivering a controlled quantity of said particulate material to said delivery conduit; and,

providing said delivery stream of gas at a selected velocity to move said particulate material through said delivery conduit.

**32.** The method as recited in Claim 31, further comprising a step of directing a substantially continuous stream of particulate material into said web forming chamber.

**33.** The method as recited in Claim 15, further comprising a step of directing an intermittent stream of particulate material into said web forming chamber.

**34.** The method as recited in Claim 15, further comprising the step of directing a substantially continuous stream of particulate material into said web forming chamber.

**35.** The method as recited in Claim 15, wherein said selective transferring step (b) comprises the steps of:

directing a first particulate material into said web forming chamber with a first transferring means; and,

directing at least a second particulate material into said web forming chamber with a second transferring means.

**36.** The method as recited in Claim 35, further comprising the step of directing a substantially continuous stream of particulate material into said web forming chamber.

**37.** A method for forming a substantially uniform distribution of particulate material in the cross-machine direction within a fibrous web, comprising the steps of:

(a) providing a gas entrained supply stream of said particulate material;

(b) transferring a selected quantity of said particulate material into a delivery gas stream to provide a flow of said particulate material through a delivery conduit and a delivery nozzle, including an end edge and having a oval shape including gaps on the end edge facing into a web forming chamber, into a web forming chamber;

(c) providing a flow of a selected fibrous material into said web forming chamber; and,

(d) receiving said fibrous material and said particulate material on a foraminous forming layer located within said web forming chamber to produce said fibrous web which includes a substantially uniform distribution of said particulate material.

**38.** The method as recited in Claim 37, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**39.** The method as recited in Claim 37, wherein said end edge of said delivery nozzle flares out from said delivery conduit.

**40.** The method as recited in Claim 39, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**41.** The method as recited in Claim 37, wherein said gaps in said end edge of said delivery nozzle are semi-circular in shape.

**42.** The method as recited in Claim 41, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**43.** The method as recited in Claim 42, wherein said end edge of said delivery nozzle flares out from said delivery conduit.

**44.** The method as recited in Claim 43, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**45.** The method as recited in Claim 37, wherein said gaps in said end edge of said delivery nozzle are semi-circular in shape.

**46.** The method as recited in Claim 45, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**47.** The method as recited in Claim 46, wherein said end edge of said delivery nozzle flares out from said delivery conduit.

**48.** The method as recited in Claim 47, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**49.** The method as recited in Claim 37, wherein said providing step (a) includes steps of:

generating a stream of conveying gas for entraining said particulate material; and,

regulating a flow of said conveying gas to provide a gas flow velocity within the range of about 5m/sec to about 45 m/sec.

**50.** The method as recited in Claim 49, further comprising steps of:

providing said delivery gas stream; and,

regulating a flow of said delivery gas stream to provide a velocity of gas flow within the range of about 5m/sec to about 45 m/sec.

**51.** The method as recited in Claim 50, further comprising a step of providing a selected, regulated mass flow rate of said particulate material within said supply stream.

**52.** The method as recited in Claim 37, further comprising the step of controlling said flow of said particulate material from said delivery conduit and said delivery nozzle into said web forming chamber.

**53.** The method as recited in Claim 37, wherein said transferring step (b) comprises steps of:

delivering a controlled quantity of said particulate material to said delivery conduit; and,

providing said delivery stream of gas at a selected velocity to move said particulate material through said delivery conduit.

**54.** The method as recited in Claim 53, further comprising a step of directing a substantially continuous stream of particulate material into said web forming chamber.

**55.** The method as recited in Claim 37, further comprising a step of directing a substantially continuous stream of particulate material into said web forming chamber.

**56.** A method as recited in Claim 37, further comprising the step of directing an intermittent stream of particulate material into said web forming chamber.

**57.** A method as recited in Claim 37, wherein said selective transferring step (b) comprises the steps of:

directing a first particulate material into said web forming chamber with a first transferring means; and,

directing at least a second particulate material into said web forming chamber with a second transferring means.

**58.** A method as recited in Claim 57, further comprising the step of directing a substantially continuous stream of particulate material into said web forming chamber.

**59.** A method for forming a substantially uniform distribution of particulate material in the cross-machine direction within a fibrous web, comprising the steps of:

(a) providing a gas entrained supply stream of said particulate material;

(b) transferring a selected quantity of said particulate material into a delivery gas stream to provide a flow of said particulate material through a delivery conduit and a delivery nozzle, including an end edge and a wedge member wherein said delivery nozzle is circular shaped, into a web forming chamber;

(c) providing a flow of a selected fibrous material into said web forming chamber; and,

(d) receiving said fibrous material and said particulate material on a foraminous forming layer located within said web forming chamber to produce said fibrous web which includes a substantially uniform distribution of said particulate material.

**60.** The method as recited in Claim 59, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**61.** The method as recited in Claim 59, wherein said end edge of said delivery nozzle flares out from the delivery conduit.

**62.** The method as recited in Claim 61, further comprising the step of positioning said delivery nozzle to provide a substantially uniform distribution of said particulate material in the cross direction of said fibrous web.

**63.** The method as recited in Claim 59, wherein said providing step (a) includes steps of:

generating a stream of conveying gas for entraining said particulate material; and,

regulating a flow of said conveying gas to provide a gas flow velocity within the range of about 5m/sec to about 45 m/sec.

**64.** The method as recited in Claim 63, further comprising steps of:

providing said delivery gas stream; and,

regulating a flow of said delivery gas stream to provide a velocity of gas flow within the range of about 5m/sec to about 45 m/sec.

**65.** The method as recited in Claim 64, further comprising a step of providing a selected, regulated mass flow rate of said particulate material within said supply stream.

**66.** The method as recited in Claim 59, further comprising the step of controlling said flow of said particulate material from said delivery conduit and said delivery nozzle into said forming chamber.

**67.** The method as recited in Claim 59, wherein said transferring step (b) comprises steps of:

delivering a controlled quantity of said particulate material to said delivery conduit; and,

providing said delivery stream of gas at a selected velocity to move said particulate material through said delivery conduit.

**68.** The method as recited in Claim 67, further comprising a step of directing a substantially continuous stream of particulate material into said web forming chamber.

**69.** The method as recited in Claim 59, further comprising a step of directing a substantially continuous stream of particulate material into said web forming chamber.

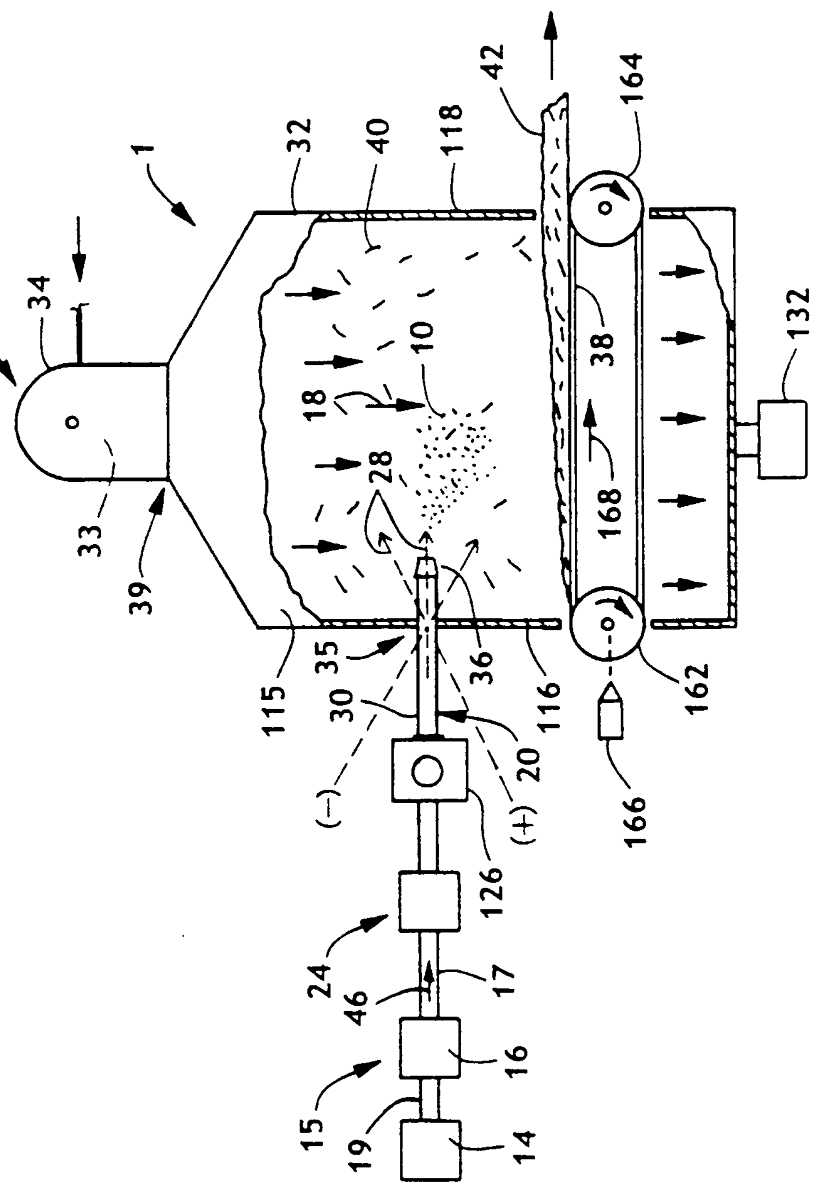
**70.** A method as recited in Claim 59, further comprising the step of directing a intermittent stream of particulate material into said web forming chamber.

**71.** A method as recited in Claim 59, wherein said selective transferring step (b) comprises the steps of:

directing a first particulate material into said web forming chamber with a first transferring means; and,

directing at least a second particulate material into said web forming chamber with a second transferring means.

**72.** A method as recited in Claim 59, further comprising the step of directing a substantially continuous stream of particulate material into said web forming chamber.



1
22
34
33
39
32
40
118
42
164
10
18
28
38
168
132
115
35
30
36
116
162
166
20
(−)
(+)
126
24
46
17
16
15
19
14


FIG. 1

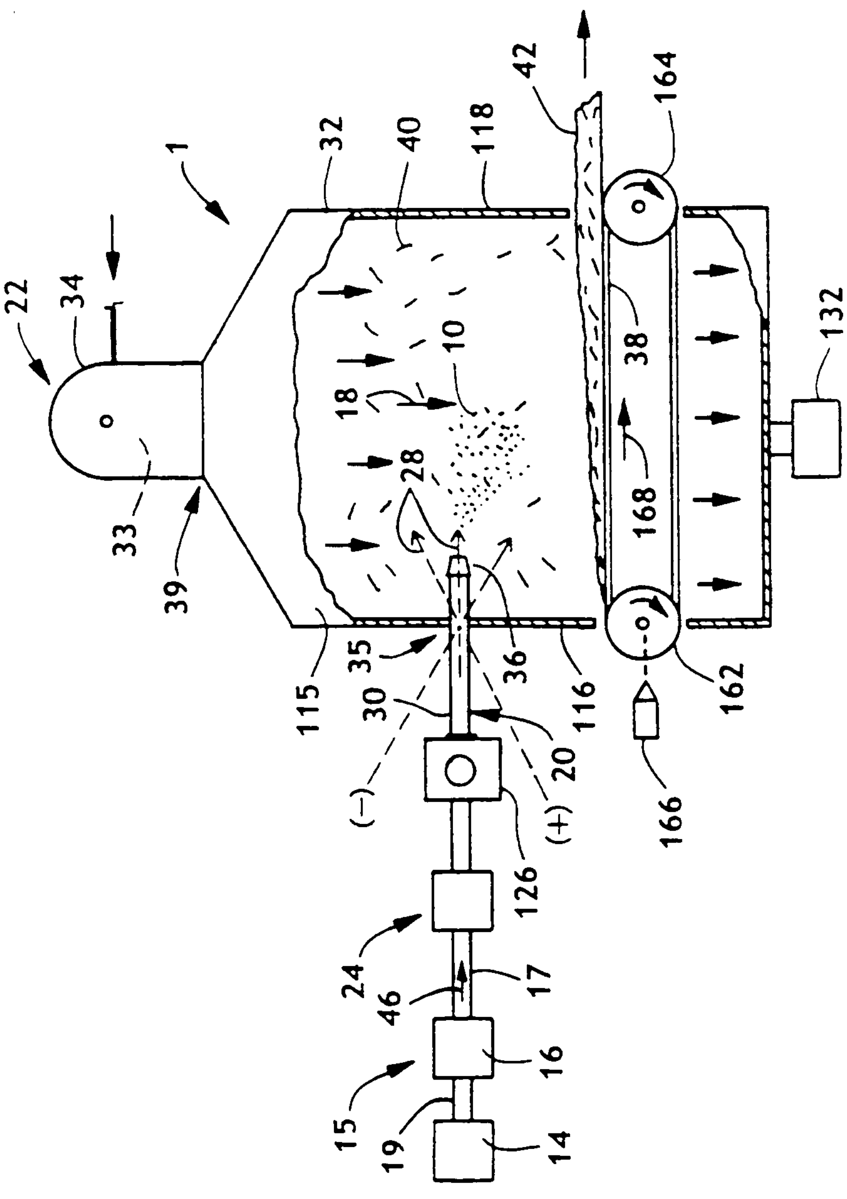

1
22
34
33
39
32
40
118
42
164
10
18
28
38
168
132
115
35
30
36
116
162
20
(−)
(+)
126
166
24
46
17
15
16
19
14

FIG. 2

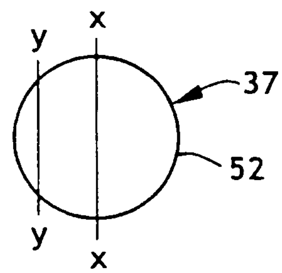



FIG. 3

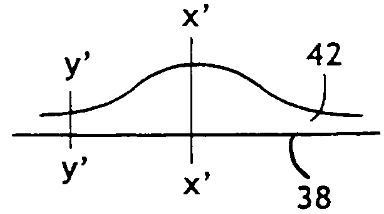



FIG. 4

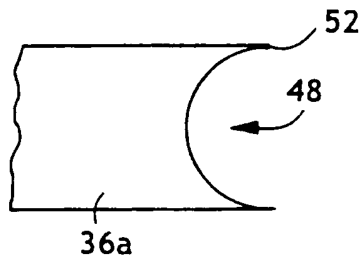



FIG. 6

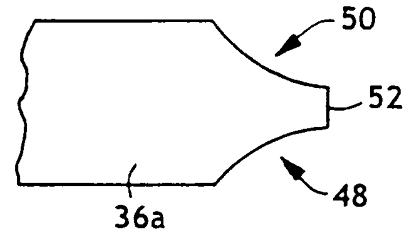



FIG. 7

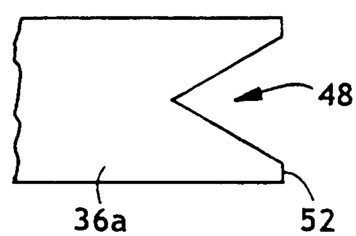



FIG. 8

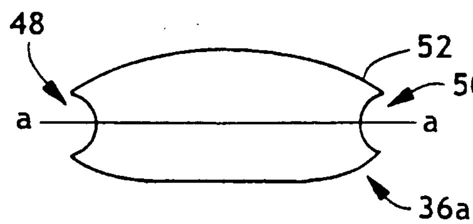



FIG. 9

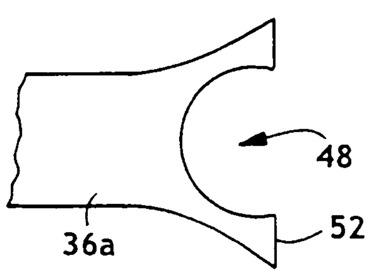



FIG. 10

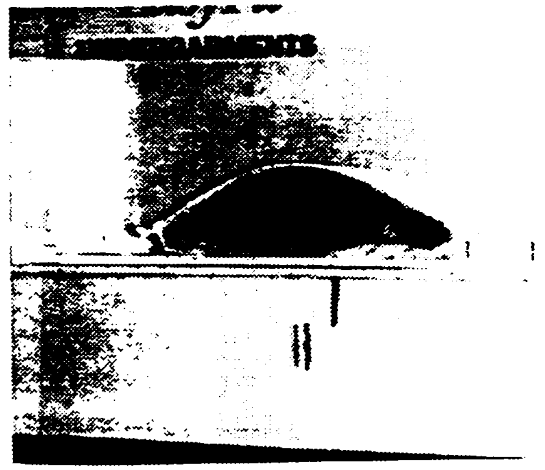


FIG. 5

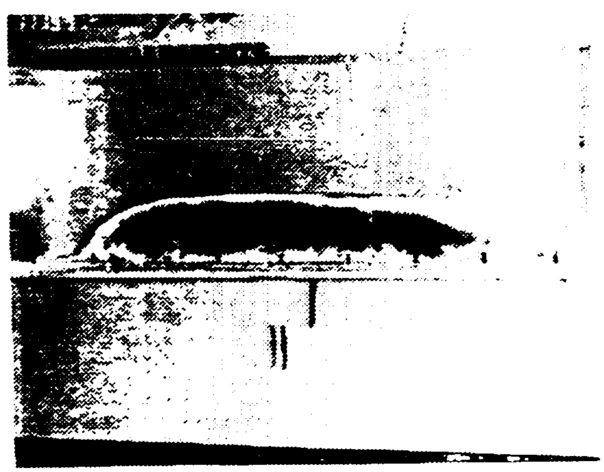


FIG. 11

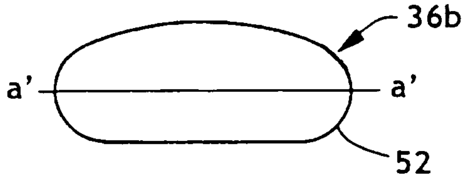



FIG. 12

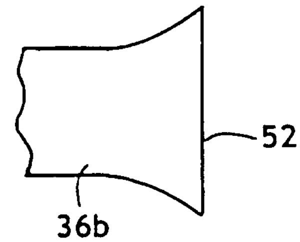



FIG. 13

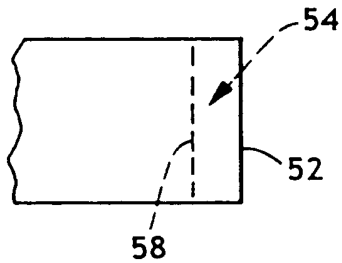



FIG. 15

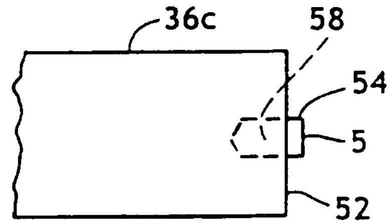



FIG. 16

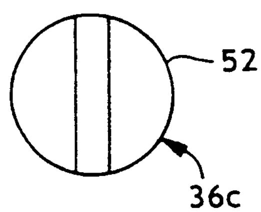



FIG. 17

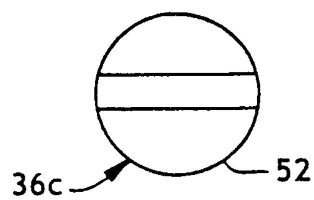



FIG. 18

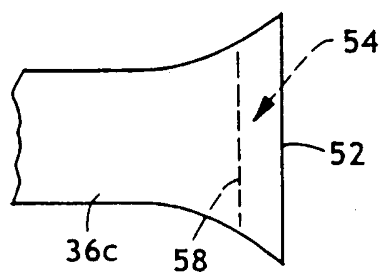



FIG. 19

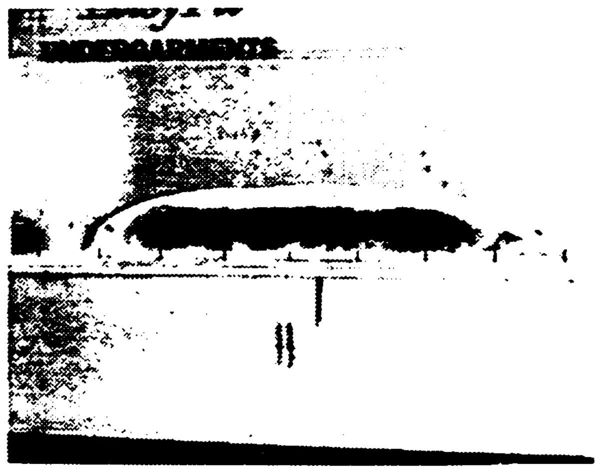



FIG. 14

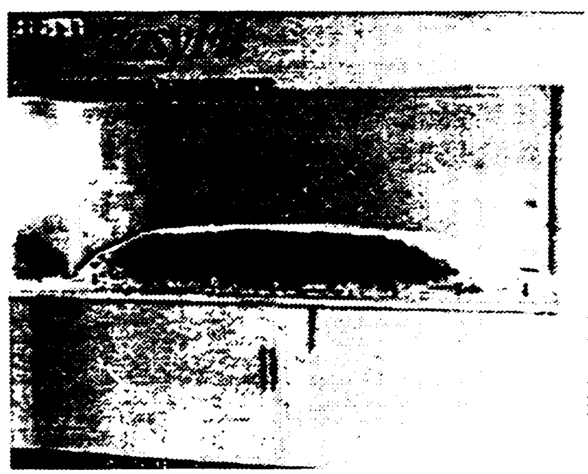


FIG. 20

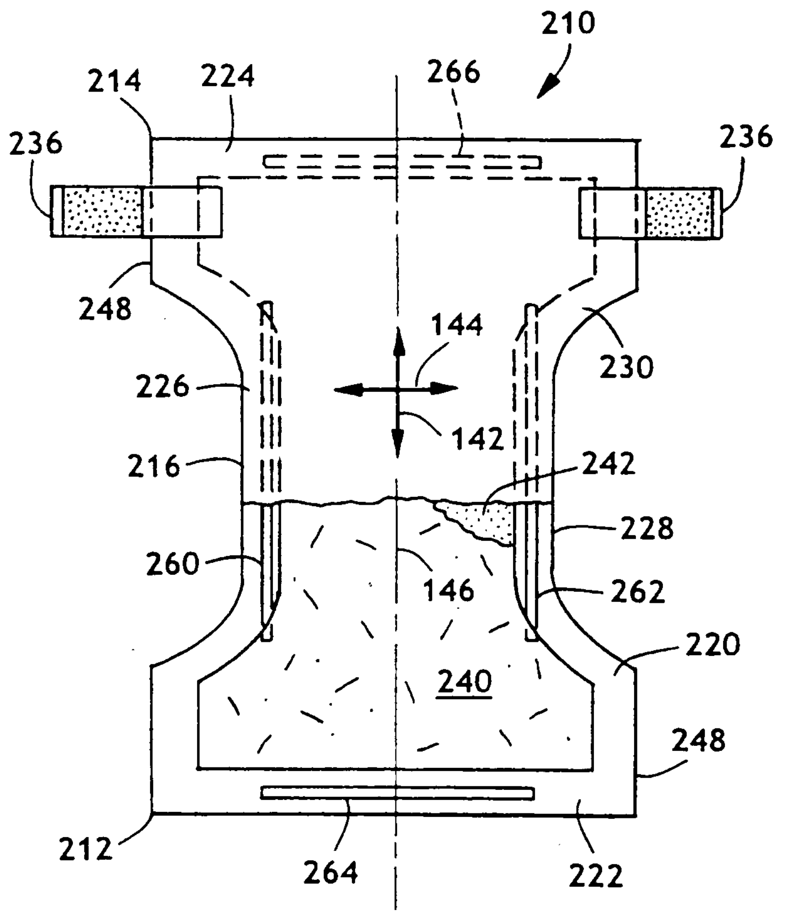

210
214
224
266
236
236
248
144
230
226
142
216
242
228
260
146
262
220
240
248
212
264
222

FIG. 21

# INTERNATIONAL SEARCH REPORT

Internation  pplication No
PCT/US 99/29470

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 A61F13/15 B05B7/14

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61F B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 5 350 597 A (PELLEY KENNETH A) 27 September 1994 (1994-09-27) column 5, line 33 - line 68 | 1,15,37, 59 |
| A | US 4 551 191 A (KOCK RONALD W ET AL) 5 November 1985 (1985-11-05) column 9, line 56 -column 10, line 65 | 1 |
| A | US 5 567 472 A (JANSON JOHN P ET AL) 22 October 1996 (1996-10-22) column 7, line 7 - line 49 | 1 |
| A | EP 0 072 654 A (ECOMAX UK LTD) 23 February 1983 (1983-02-23) | 15 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 9 May 2000 | 18/05/2000 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | V Beurden-Hopkins, S |

1

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/29470

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 5350597 A | 27-09-1994 | US 5213817 A | 25-05-1993 |
| | | AT 149001 T | 15-03-1997 |
| | | AU 662370 B | 31-08-1995 |
| | | AU 2989392 A | 17-06-1993 |
| | | BR 9204995 A | 15-06-1993 |
| | | CA 2084841 A | 13-06-1993 |
| | | CN 1080513 A | 12-01-1994 |
| | | CZ 284496 B | 16-12-1998 |
| | | DE 69217541 D | 27-03-1997 |
| | | DE 69217541 T | 18-09-1997 |
| | | DK 547549 T | 25-08-1997 |
| | | EG 19956 A | 31-10-1996 |
| | | EP 0547549 A | 23-06-1993 |
| | | ES 2100265 T | 16-06-1997 |
| | | FI 925635 A | 13-06-1993 |
| | | GR 92100544 A,B | 31-08-1993 |
| | | HK 114697 A | 29-08-1997 |
| | | HU 66851 A,B | 30-01-1995 |
| | | JP 5277147 A | 26-10-1993 |
| | | MX 9207183 A | 01-07-1993 |
| | | PL 296976 A | 24-01-1994 |
| | | SK 361092 A | 07-06-1995 |
| | | US 5614147 A | 25-03-1997 |
| | | ZA 9209645 A | 13-06-1994 |
| US 4551191 A | 05-11-1985 | AT 43078 T | 15-06-1989 |
| | | AU 566858 B | 29-10-1987 |
| | | AU 4429485 A | 08-01-1987 |
| | | CA 1253752 A | 09-05-1989 |
| | | DE 3570193 D | 22-06-1989 |
| | | EP 0168196 A | 15-01-1986 |
| | | ES 544678 D | 01-06-1986 |
| | | ES 8607763 A | 16-11-1986 |
| | | ES 544690 D | 01-06-1986 |
| | | ES 8607762 A | 16-11-1986 |
| | | JP 2057809 C | 10-06-1996 |
| | | JP 7084692 B | 13-09-1995 |
| | | JP 61092859 A | 10-05-1986 |
| | | KR 9404020 B | 11-05-1994 |
| US 5567472 A | 22-10-1996 | US 5558713 A | 24-09-1996 |
| | | AU 4137496 A | 23-05-1996 |
| | | CA 2203137 A | 09-05-1996 |
| | | EP 0789627 A | 20-08-1997 |
| | | JP 10507967 T | 04-08-1998 |
| | | WO 9613335 A | 09-05-1996 |
| EP 0072654 A | 23-02-1983 | NONE | |